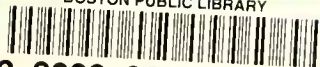


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POCKET GOPHERS AND REFORESTATION IN THE PACIFIC NORTHWEST: A Problem Analysis

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Special Scientific Report—Wildlife No. 155

UNITED STATES DEPARTMENT OF THE INTERIOR
Fish and Wildlife Service
Bureau of Sport Fisheries and Wildlife

**POCKET GOPHERS AND REFORESTATION IN THE PACIFIC NORTHWEST:
A PROBLEM ANALYSIS**

By

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ABSTRACT

Pocket gophers (Thomomys spp.) have an important effect on reforestation in the Pacific Northwest through damage to conifer reproduction. Damage is most serious east of the Cascade Range in Washington and Oregon (Canutt, 1969a; Crouch, 1969) and northeastern California (Packham, 1969). Damage also has been reported in northern Idaho (Kuck, 1969). The purpose of this report is to review pocket gopher problems in the Northwest, summarize present knowledge of gopher biology, outline current control methods, and suggest future research needs.

THE PROBLEM

Pocket gopher damage to forest crops was reported as early as 1940 (Moore, 1940), but there were few reports (Moore, 1943; Dingle, 1956; Tevis, 1956; Oregon Department of Forestry, 1961; Hermann and Thomas, 1963) until recent years, when damage by pocket gophers acquired top priority as a reforestation problem. This increased importance is the result of intensified management and recognition that gophers are responsible for some damage previously attributed to porcupines (Erethizon dorsatum) (Moore, 1940; Crouch, 1969). Although most damage to date has been on ponderosa pine (Pinus ponderosa) plantations, a growing interest in lodgepole pine (P. contorta) management will undoubtedly focus more attention on gophers in that forest type.

The pocket gopher-reforestation problem is analogous to many other forest-wildlife situations. The animals are widely distributed in timber stands, but primarily concentrated in mesic sites such as river banks, spring areas, meadows, and other breaks in the forest canopy where ground vegetation provides ample forage. Openings created by harvest or wildfire, and the successional vegetation that follows, improve gopher habitat. Although quantitative data are lacking, it appears that substantial gopher populations can become established on these areas in 2 to 3 years. Since the current trend is to plant or seed soon after the forest has been opened, gopher densities often are high when seedlings are young and most vulnerable. On some areas it has been noted that establishment of brush is accompanied by a reduction in forb and grass cover and in pocket gopher density. However, this natural or successional process is slow, and tree stocks often are severely depleted before brush becomes a dominant factor.

Types of damage

The two most common forms of tree damage by gophers are root pruning and a combination of stem girdling and clipping. Stems of small seedlings (basal diameters of 1/2 inch or less) are cut into two or more sections. Seedlings are frequently clipped at or near ground level and the roots or the stems are taken. Gophers also remove entire seedlings and leave only burrows or plugged holes as evidence. Root pruning and girdling of small seedlings occur year-round but are most frequent in winter.

Root pruning on larger seedlings and saplings also occurs year-round. The seasonal frequency has not been determined, primarily because damage generally does not become evident until long after the trees have been injured. In addition, some trees probably incur damage over a period of several years. Root-pruned trees are detected when they begin to tilt or change color.

Clipping and girdling on larger trees occurs primarily under snow cover. Logically, this damage is more prevalent in areas where heavy snowpacks persist. Girdling is often complete, leaving white stalks that are easily spotted in spring. Extensive winter girdling has been observed on the Dugout Lake burn west of Sisters, Ore., and the Johns-Manville clearcuts near the east border of Crater Lake National Park. Girdling at heights above 7 feet has been observed on lodgepole pine at the Dugout Lake burn.

Other types of tree damage caused by gophers include root exposure by burrowing (Tevis, 1956) and burying of seedlings by winter casts or mounds (Kuck, 1969). It seems likely that root exposure would most often occur in conjunction with root gnawing and girdling. Only very small seedlings, probably resulting from natural or artificial seedfall, would be damaged by casts or mounds. This latter type of damage might be offset by the favorable seedbeds created by gopher soil disturbances (Tevis, 1956; Larrison, 1942). Root exposure and burying usually are of minor importance in comparison with other types of damage.

An indirect effect of pocket gophers on ponderosa pine was reported by Moore (1943). He concluded that lack of natural reproduction in forest openings of the Ochoco National Forest was due to seed foraging by white-footed deer mice (Peromyscus spp.) using gopher burrows as shelter. He felt that mice were less efficient in collecting seed on areas where gophers had been removed.

Significance of damage

Factors relating to pocket gophers and tree damage are not well understood, although it is known that severity of damage varies considerably with habitat type, weather conditions, and gopher population fluctuations. Dingle (1956) reported losses of 12 percent in 1 year and 30 percent in 2 or 3 years on ponderosa pine plantations in eastern Washington. Hermann and Thomas (1963) recorded substantial gopher losses in ponderosa pine over a 10-year period on an Oregon plantation. More recent investigations by G.L. Crouch (USFS Pacific Northwest Forest and Range Experiment Station, personal communication) and ourselves on Cave Mountain burn in south-central Oregon have indicated that annual seedling mortality on plantations in the ponderosa pine zone might vary from 5 to 50 percent. Our studies at Dugout Lake burn, at about 5,000-foot elevation in a lodgepole-ponderosa pine transition zone, indicate the damage potential in heavy snowfall areas. In 1 year, gophers destroyed 67 percent of the planted ponderosa pine seedlings on two 20-acre study units, and approximately 92 percent of that mortality occurred between October and June.

The only available published data on lodgepole pine damage were obtained from a regeneration study in western Colorado. Ronco (1967) found that gophers killed from about 3 to 30 percent of the lodgepole pine seedlings on his plots each winter. Summer mortality averaged near 1 percent. In the same study, gopher-caused mortality to Engelmann spruce (*Picea engelmannii*) seedlings varied from zero to about 25 percent over winter and averaged less than 1 percent during summer. A later study by Ronco (1970) revealed that gophers caused from 4 to 54 percent annual mortality of spruce seedlings during a 5-year period.

Economics

The importance of gopher damage in the Northwest generally has been expressed in terms of geographic distribution or an arbitrary ranking among other types of wildlife damage. The lack of sufficient damage information from throughout the region precludes a true economic analysis. However, there are records for some plantations that roughly indicate the economic impact of pocket gophers on forest land.

The history of Cave Mountain burn illustrates the reforestation losses that can occur on gopher-occupied habitat. A wildfire in 1959 was followed by ponderosa pine plantings in 1961, 1962, and 1963; by 1965 the 1,500-acre plantation was considered a failure. Pocket gophers were judged to be the single greatest loss factor, although weather, disease, domestic livestock, and other wildlife certainly were responsible for substantial losses. Since 1965, gopher control (baiting) has been largely unsuccessful. Economic losses to date include approximately \$200,000 in planting costs plus an annual \$9,000 loss of estimated growth potential (450 thousand board feet per year) (Canutt, 1970).

Noteworthy losses can also occur on smaller plantations. For example, the 170-acre Dugout Lake burn was first planted in 1964, and by 1968 the stocking had been virtually eliminated. Gophers are believed to have been a major cause of the failure, and our current studies support that conclusion. The lost investment of the first planting totaled \$15,000 (planting plus animal damage control). The burn was replanted in 1969, and success to date has been marginal because of weather factors and animal damage. The total cost of the second planting has reached about \$14,000; this includes about \$2,000 for one animal repellent treatment to prevent deer browsing and roughly \$3,500 for two baiting operations to control gophers (D. Rowe, Sisters Ranger District, personal communication).

BIOLOGY

Control of animal damage is most effective when based on sound ecological principles. As Canutt (1970) pointed out, there is a need for basic ecologic information relevant to gophers and forest management. Control work on forest land currently is based on pocket gopher research related to range and agricultural problems. Continued development and improvement of control methods will depend on research directly applicable to reforestation problems. This section is included to expose some of the factors and problems of gopher control and to provide a foundation for future research specific to the forest damage problem.

The following is a general summary of the biology of the genus Thomomys, and reference to specific populations is not intended. The genus is remarkably adaptable, as indicated by its wide geographical and ecological distribution; certain characteristics will differ importantly even between local populations. This inherent variability of gopher populations is a major problem in management of the animal (Crouch, 1942).

Taxonomy and distribution

Ingles (1965) lists six species of Thomomys occurring in Washington, Oregon, and California. The northern and mazama pocket gophers (T. talpoides and T. mazama) are widely distributed from the Canadian border to northeastern California and are probably the two species most common in the presently recognized damage areas. They are virtually indistinguishable by external characteristics. The Botta gopher (T. bottae) is found throughout almost all of California and extends into southwestern Oregon. The mountain pocket gopher (T. monticola) in east-central California and the Townsend gopher (T. townsendii) in northeast California and southeast Oregon have more limited distribution. The large Camas pocket gopher (T. bulbivorus) is confined to the Willamette Valley in Oregon and is of little concern to foresters.

General habits

Gophers occupy burrow systems that provide shelter and access to forage. The systems consist of runways 4 to 18 inches below the ground surface. Side tunnels off the main runways are used as exits from the system and for deposition of soil, debris, excess food, and feces. Larger chambers are used for nest sites and food storage. Moore and Reid (1951) found that burrow systems may contain more than one nest

cavity, and reported nests down to 5 feet below the surface. The burrow system is a closely regulated microenvironment, and the gopher will generally plug any openings in the system within 48 hours--often within 24 hours. This plugging trait of gophers can be used to evaluate the success of control operations (Miller, 1953; Richens, 1967; Barnes, Martin, and Tietjen, 1970).

The typical horseshoe-shaped mounds pushed up by gophers are the result of soil excavated as they extend and repair their burrow systems. Mound-building is most common in late summer and fall when young-of-the-year are establishing burrow complexes and older animals are enlarging systems in preparation for winter. It is during this period that the above-ground signs of activity can be counted to estimate gopher abundance (Richens, 1965; Reid, Hansen, and Ward, 1966). A more difficult sign to detect is the small circle of disturbed soil at the ground surface, commonly known as an earth plug. These plugs are usually formed where gophers have emerged to forage and plugged the hole upon re-entry. In spring and early summer, plugs may be the only soil indicators of gopher activity.

In winter, gophers extend their systems into the snow, apparently to facilitate their search for food. Later, excess soil is pushed into these snow burrows to create the ribbonlike "winter casts" that become evident as the snow melts. Since these casts indicate winter activity, they also pinpoint areas where damage can be expected. Winter casts should not be confused with the surface ridges created by moles (Talpidae).

Gophers are solitary animals except during the breeding season and when females are rearing young. During most of the year, each system serves as both the territory and the home range of an individual gopher. After the young have dispersed and established their own burrow systems, territories are thought to remain stable and mutually exclusive until the following spring breeding season (Hansen and Miller, 1959). Both Tryon (1947) and Ingles (1965:206-211) reported that gophers vigorously defend their territories against others of their own kind.

Reproduction

The time and length of the breeding season of Thomomys apparently is quite variable throughout its range. Miller (1946) summarized a number of reports on breeding data in the Northwest and concluded that the breeding season is limited to the spring months in the northern portions and at higher elevations, but might extend from fall through spring in southern localities. Continuing, he stated that the number of litters per year can vary from one to three. Although Wight (1930)

and Horn (1923) documented two litters per year in eastern Oregon, single litters probably are most common east of the Cascade summit (Scheffer, 1931). The number of young per litter can range from 2 to 12 (Ingles, 1965; Colorado Cooperative Pocket Gopher Project Technical Committee, 1960); average litter sizes generally range from 3 to 7 (Miller, 1946; Tryon, 1947; Moore and Reid, 1951; Hansen, 1960). The gestation period is reported as approximately 19 days (Schramm, 1961; Ingles, 1965).

Populations

Pocket gopher populations are dynamic and, according to Aldous (1957), exhibit random fluctuations. Rapid natural die-offs have been reported by Howard (1961) and Hansen (1962). In Colorado, Reid, Hansen, and Ward (1966) found gopher densities ranging from 3 to 34 per acre, and in Utah, Richens (1965) reported from 12.5 to 39.3 animals per acre under varying degrees of control. The annual turnover in gopher populations is high; juveniles (1 year old or less) may account for more than 75 percent of the population at peak levels of the year (Tryon, 1947; Hansen, 1960).

Food habits

A number of studies have investigated the food habits of Thomomys on rangelands, including those reported by Aldous (1951), Moore and Reid (1951), Ward and Keith (1962), Hansen and Ward (1966), and Tietjen et al. (1967). In summary, there is a general preference for forbs over grasses. Consumption of woody plants generally occurs when more preferred species are unavailable. Above-ground parts of plants are taken with greatest frequency in spring and summer, while below-ground portions become more important during winter. Keith, Hansen, and Ward (1959) demonstrated that gopher feeding habits will change when vegetative composition is altered. However, as Tietjen et al. (1967) pointed out, a marginal diet reduces the ability of gophers to survive, and reduced populations are a likely result.

Animal associations

A variety of animals may occupy active or abandoned gopher burrows and must be considered when control is anticipated. Some of the most common associates of gophers are deer mice, pocket mice (Perognathus spp.), kangaroo rats (Dipodomys spp.), voles (Microtus spp.), ground squirrels (Citellus spp.), and weasels (Mustela spp.). In addition, numerous reptiles and amphibians have been observed or captured in gopher runways (Howard and Childs, 1959; Vaughn, 1961; Hansen and Ward, 1966).

Population regulators

Several natural factors reduce pocket gopher numbers, although it appears that very few significantly affect ultimate population levels. Howard and Childs (1959) suggested that territoriality might have an influence, but felt that it was subordinate to food and cover. The effect of parasitism also has been considered insignificant (Tryon, 1947). Predation is another factor to consider. The major predators include weasels, coyotes (Canis latrans), bobcats (Lynx rufus), badgers (Taxidae taxus), great horned owls (Bubo virginianus), great grey owls (Strix robulosa), barn owls (Tyto alba), hawks (Buteo spp.), and snakes (Tryon, 1947; Moore and Reid, 1951; Howard and Childs, 1959; Hansen and Ward, 1966). Dispersing juveniles probably are the most vulnerable to predation, since they have no established burrow systems and sometimes travel above ground (Howard and Childs, 1959). Tryon (1947) believed that gophers were as easily preyed upon as other rodent species, but felt the overall effect of predation on populations was small. Hansen and Ward (1966) concurred, adding that the effect of predation was to slow the rate of increase rather than prevent a population peak.

Weather and vegetation probably have the greatest effect on population levels. Hansen and Ward (1966) believed that the depth and water content of snow affected the survival of young and thus exerted an influence on population density. They indicated that the quantity and quality of forage, as affected by characteristics of the growing season (length, temperatures, moisture) were also important. Moore and Reid (1951) reported that a rise in the water table could cause significant mortality.

DAMAGE CONTROL METHODS

Basic approaches

Direct control of damaging animals is the most widely used approach to alleviate gopher damage, and trapping and poisoning are the techniques most often employed. Other methods that have been used include flooding, fumigation, shooting (Crouch, 1942), and exclosures and caging (Dixon, 1922; Keith, 1961). In addition, reproductive inhibitors (Hipply, 1969) and repellents (D.E. Howell, Oklahoma State University, personal communication) appear promising but need further investigation. The introduction of disease also has been suggested, but Scheffer (1931) and Crouch (1942) were pessimistic of the idea.

Indirect or ecological control involves habitat modification, usually to make the target area less suitable for gopher occupation. On range and agricultural lands this can be accomplished with

herbicides or crop rotation (Colorado Cooperative Pocket Gopher Project Technical Committee, 1960). Application of 2,4-D herbicide in Colorado reduced gopher populations by 80 to 90 percent, and repopulation of treated areas has in general been slow. Success was attributed to decreased forb production (Keith, Hansen, and Ward, 1959; Hansen and Ward, 1966; Tietjen et al., 1967).

Other possibilities of habitat manipulation that have been advanced include the introduction of plant species or buffer foods that would divert feeding from the valued crop. Storer (1945) suggested that gophers could be controlled by destroying their burrows.

Control of damage on forest lands

Trapping.--Trapping has been used on forest lands to a limited extent. It is extremely slow and time consuming and is practical only on small areas or as a supplement to other forms of damage control. Consequently, there appear to be few forest situations where trapping would be feasible. Several types of traps are available, although the Macabee kill-trap probably is the most popular (Crouch, 1942; Colorado Cooperative Pocket Gopher Project Technical Committee, 1960).

Hand-baiting, mechanical bait dispenser.--Baiting by hand is a much faster operation than trapping and is safe and effective when done properly. The technique requires three steps: (1) location of a runway by probing or excavation; (2) placement of the toxic bait in the burrow by hand, spoon, or other appropriate means; and (3) covering of the exposed burrow. Specific procedures and types of bait for this technique are well documented (Crouch, 1942; Moore and Reid, 1951; U.S. Fish and Wildlife Service, 1952; Colorado Cooperative Pocket Gopher Project Technical Committee, 1960). Hand-baiting has been used on forest plantations, but its effectiveness has not been evaluated. Canutt (1970) cited a report from the Umatilla National Forest in northeastern Oregon that estimated the cost of hand-baiting at less than \$6 per acre. He equated this figure with the cost of treating approximately 5 acres of densely populated agricultural land.

An improvement over hand-baiting is the mechanical bait dispenser--it is faster and just as efficient (Hansen, 1956). This device allows an operator to locate (probe) a runway and deposit bait in the same operation. With this device Canutt (1970) was able to dispense bait at the rate of 1 acre per hour.

Hand-baiting or the bait dispenser may be useful for control on small acreages or with isolated populations, or to maintain control and prevent invasion. However, use of the techniques on large plantations

might be impractical. There are indications that efficiency decreases rapidly on areas exceeding 5 acres (H.P. Tietjen, Denver Wildlife Research Center, personal communication).

Burrow-builder.--The introduction of the burrow-builder in the late 1950's was an important development in pocket gopher control. In principle, the burrow-builder creates an artificial burrow, by means of a subsurface torpedo, and in the same operation places bait in the burrow. Prototypes were developed almost simultaneously in Colorado (Ward and Hansen, 1960) and California (Kepner et al., 1961). Subsequent reports have detailed construction methods, modifications, and evaluation techniques for use in agricultural areas (Colorado Cooperative Pocket Gopher Project Technical Committee, 1960; Sargeant and Peterson, 1964; Marsh and Cummings, 1968). A reinforced model, called the forest-land burrow-builder, was developed for use in more rugged forest terrain (Canutt, 1969b) and has been successfully used to apply toxic oat baits to reduce gopher populations on forest plantations (Packham, 1969; Barnes, Martin, and Tietjen, 1970).

The efficiency of the burrow-builder depends on a number of variables, including topography, soil texture, soil moisture, and obstructions. Accordingly, Canutt (1970) estimated that the machine could be used to treat from 2.5 to 6 acres per hour. He reported cost estimates of \$2.65 and \$7.35 per acre for two projects on the Winema National Forest. Packham (1969) estimated that approximately 28 acres could be treated per day at a cost of about \$6 per acre.

Analysis of baiting.--Many benefits have been derived from pocket gopher baiting programs, and the technique is the most common in use today. However, baiting has limitations that should be recognized. First, treatment must be done expertly to assure effectiveness, since mortality of less than 75 percent generally is no greater than would occur naturally. Second, even effective baiting provides only temporary relief. This is an important concept, since tree protection may be necessary for 10 years or more. Complete reduction rarely, if ever, occurs, and offspring of survivors will quickly repopulate unoccupied systems. In many areas, invasion from uncontrolled populations can also be expected (Storer, 1945). Not only will an abundance of unoccupied systems likely increase survival of dispersing young, but reduced population densities might temporarily stimulate reproduction. Studies by Moore and Reid (1951), Richens (1965), and Julander, Low, and Morris (1969) have demonstrated that persistent baiting is necessary on rangeland to maintain control. This same problem has become apparent on forest lands, where we have noted reinvasion 3 to 4 months after treatment.

An equally important consideration is that the pesticides and baits currently in use are not necessarily specific to gophers, and nontarget wildlife may be in jeopardy of poisoning. Secondary hazards to predator species appear to be lessened by the tendency of gophers to die underground (Ward et al., 1967), but could still be a problem in some areas.

Use of the burrow-builder on forest lands introduces additional factors not encountered with hand-baiting. Initial site preparation often is desirable or even necessary to make pathways for the machine. The additional cost probably is not important considering the machine's efficiency, but the resulting soil disturbance can promote forb development and increase the potential for gopher repopulation. In addition, the artificial burrows may persist a year or more, and the possibility that they expedite reinvasion should not be discounted. One of the most critical factors governing the use of the burrow-builder is soil moisture. In dry climates, where most gopher-reforestation problems occur, use of the machine is restricted to periods in spring and fall. Moisture requirements can usually be met in spring, but reinvasion will necessitate fall treatment in most cases. Fall moisture is unpredictable and at higher elevations may first appear in sufficient quantity as snow. The necessity of last-minute scheduling places an added burden on management.

Operational use of the burrow-builder on forest land is a recent development; the significance of these factors and the effectiveness of long-term burrow-builder treatment are unknown. Nevertheless, burrow-builder treatment, where usable, currently is the best technique for reducing tree damage by pocket gophers.

RESEARCH NEEDS

The need for continued pocket gopher research on timber-producing lands is apparent. The following outline identifies important research problems and is intended to serve as a guide to interested researchers for cooperative and complementary efforts.

Control research

A. Burrow-builder evaluation.-- Since the burrow-builder presently is the most practical method for baiting gophers, it is essential that the technique be evaluated on a long-term operational basis.

B. Control mortality factors.--Although methods exist for estimating population reduction, specific effects of baiting--where mortality occurs, how long before mortality occurs, and how long bait

is available and effective--are not known. Answers to these questions could suggest ways to improve baiting effectiveness and also indicate potential secondary hazards and other sources of nontarget mortality.

C. Habitat manipulation.--Probably the greatest potential for effective, long-lasting control is through habitat manipulation. Forage appears to be one of the most critical factors determining population levels, and high priority should be given to the development of safe and efficient methods of limiting production of essential gopher foods. The effects of herbicides, brush, introduced plant species, and forest management practices need thorough investigation.

D. Repopulation.--Population recovery on treated areas has two sources--reproduction by survivors and invasion from adjacent areas. The impact of the former is dependent on control efficiency, further stressing the need to investigate control success and related factors. The invasion problem is particularly difficult, since it usually originates from populations on land that is not accessible to machine baiting or is not managed for timber production. Invasion on small plantations (less than 50 acres) probably can be countered only by periodic treatment. Buffer strips might effectively restrict invasion on large plantations, but more data are needed on distances and other factors relating to the time it takes gophers to invade unoccupied habitat. Our studies so far suggest a minimum distance of about 1,000 feet per year for moderate to high gopher populations.

E. Evaluation of new animal damage control agents.--Various agencies continue testing potential damage control agents that may prove to be more effective, more specific, or safer to man and nontarget wildlife. Agencies or companies concerned with pocket gopher damage should be prepared to participate in the evaluation of new control agents that warrant field testing.

F. Evaluation of hand-baiting.--There are areas that are too extensive for trapping and too rocky or inaccessible for the burrow-builder where baiting by hand or with a bait dispenser is probably the only practical means of control. Studies should be conducted to evaluate the technique and develop procedures for maximum efficiency.

G. Winter baiting.--In 1970, we conducted a preliminary study of winter bait acceptance. Results were negative, but winter baiting remains a possibility and should receive further study.

H. Repellents.--Repellents have been used successfully to protect buried cable (Tigner and Landstrom, 1968) and fruit trees (D.E. Howell, Oklahoma State University, personal communication) from gopher damage

and have potential for tree protection on forest land. Studies are needed to determine the reaction of gophers to various repellents and also the effects of repellents on tree survival and growth.

I. Secondary hazards, nontarget mortality.--There is increasing demand for control programs that are specific to the target animals. Studies are needed to determine the direct and indirect toxicity of both traditional and experimental toxicants to predators and other animal associates of gophers.

J. Foam or grease carriers, grooming inhibitors, long-lasting baits.--Toxic foam or grease placed in artificial burrows might provide more lasting control than bait. Development of a bait that resists breakdown has also been suggested. Another idea has been the inclusion of wetting agents or tacky substances in the soil or burrows to inhibit grooming and cause gophers to avoid certain areas, abandon their systems, or become less able to survive. The feasibility of these ideas should be investigated in the laboratory.

K. Mechanical barriers.--Although enclosing trees in individual cages or area exclosures probably would not be economical in most forest situations, net tubing or repellent-coated tubing might be practical. Net tubing has shown promise as a means of reducing seedling damage by black-tailed deer (Odocoileus hemionus) and snowshoe hare (Lepus americanus) (Campbell, 1969).

L. Reproductive inhibitors.--The development of effective methods for controlling reproduction is complex. Major difficulties with gophers would be the long breeding season, variation in onset and cessation of breeding (latitude and altitude factors), and breeding under snow cover. However, a specific and effective reproductive inhibitor might be more acceptable to the public than poison bait.

Ecological research

A. Population.--Population density, sex and age composition in various habitats, the relationship of population density to tree damage, and the response of populations to land management are important data needed. They would indicate habitat requirements and limiting factors, be useful for evaluating control, and be valuable for predicting future problem areas.

B. Food habits.--Knowledge of the preferred and essential foods of pocket gophers in lodgepole and ponderosa pine habitats is especially important in the development of habitat control methods. There is currently no quantitative information available on the feeding habits of gophers as they relate to reforestation.

C. Seasonal activity, movements.--The effectiveness of control is dependent on many factors, such as timing, application rate, spacing, size of treatment area, and size of buffer strips. These factors cannot be given rational consideration without knowledge of the seasonal movement and activity patterns of adult and juvenile animals.

D. Reproduction.--Data on breeding season, litter size, and number of litters per year have utility for evaluating long-range effects of control, especially where the control methods alter the habitat. This information also is needed for development of reproductive inhibitors.

Behavioral research

Studies of food-handling and grooming behavior, factors of food selection, and the effects of temperature and moisture on feeding behavior could reveal important relationships not detectable under field conditions. In addition, knowledge of the response of individual animals to introduced substances will be necessary in evaluating several techniques that have been proposed (toxic foam, tacky substances).

Damage appraisal

The existence of a pocket gopher-reforestation problem is evident, but quantitative data on gopher damage in different habitats are lacking. Detailed damage surveys are needed throughout the Northwest. Although research agencies have been responsible for gathering most of the damage information now available, the opportunity for collection of information at the local management level should be considered.

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